

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Currently amended) An abnormality diagnosis apparatus for diagnosing abnormality of a recirculating liquid cooling system for an internal combustion engine, wherein the cooling system includes a radiator, a circulation line system, which circulates liquid coolant through the internal combustion engine and the radiator and includes a bypass fluid line that bypasses the radiator, a flow rate control means for controlling a bypass flow rate of ~~the~~liquid coolant flowing through the bypass fluid line, and a coolant temperature sensor, which measures a coolant temperature ~~of the coolant~~ in the circulation line system, the abnormality diagnosis apparatus comprising:

a coolant temperature control means for controlling the coolant temperature ~~of the coolant~~ in the circulation line system by controlling the flow rate control means; and

an abnormality diagnosis means for diagnosing the flow rate control means to determine whether an abnormality ~~of the flow rate control means~~ exists based on behavior of the measured coolant temperature, which is measured through the coolant temperature sensor during a warm-up period of the internal combustion engine.

2. (Currently Amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~as in claim 1, wherein the flow rate control means includes at least one of a valve and a pump inserted in the circulation line system.

3. (Currently Amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~as in claim 1, wherein the abnormality diagnosis means determines the existence of the abnormality of the flow rate control means based on one of:

an amount of change in the measured coolant temperature measured through the coolant temperature sensor; and

a rate of change in the measured coolant temperature measured through the coolant temperature sensor.

4. (Currently Amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~as in claim 1, wherein the abnormality diagnosis means sets an abnormality diagnosis condition, which is used to determine the existence of the abnormality of the flow rate control means, based on:

a parameter, which relates to an amount of heat generated by the internal combustion engine; and

a parameter, which relates to an amount of heat released from the coolant.

5. (Currently Amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~as in claim 4, wherein:

the abnormality diagnosis means determines an estimated coolant temperature of the coolant in the circulation line system based on:

the parameter, which relates to the amount of heat generated by the internal combustion engine; and

the parameter, which relates to the amount of heat released from the coolant; and

the abnormality diagnosis means determines the existence of the abnormality of the flow rate control means through comparison of the estimated coolant temperature and the measured coolant temperature measured through the coolant temperature sensor.

6. (Currently Amended) ~~The~~An abnormality diagnosis apparatus according to ~~claim 1, for diagnosing abnormality of a cooling system for an internal combustion engine, wherein the cooling system includes a radiator, a circulation line system, which circulates coolant through the internal combustion engine and the radiator and includes a bypass fluid line that bypasses the radiator, a flow rate control means for controlling a bypass flow rate of the coolant flowing through the bypass fluid line, and a coolant temperature sensor, which measures a coolant temperature of the coolant in the circulation line system, the abnormality diagnosis apparatus comprising:~~

a coolant temperature control means for controlling the coolant temperature of the coolant in the circulation line system by controlling the flow rate control means; and

an abnormality diagnosis means for diagnosing the flow rate control means to determine whether abnormality of the flow rate control means exists based on behavior of the measured coolant temperature, which is measured through the coolant temperature sensor during a warm-up period of the internal combustion engine;

wherein the abnormality diagnosis means corrects an abnormality diagnosis condition, which is used to determine the existence of the abnormality of the flow rate control means, based on one of:

the bypass flow rate; and

a bypass flow rate parameter, which correlates with the bypass flow rate.

7. (Currently amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~
as in claim 6, wherein the abnormality diagnosis means uses a controlled variable of the flow rate control means as the bypass flow rate parameter.

8. (Currently amended) ~~The~~An abnormality diagnosis apparatus ~~according to~~
claim 1, for diagnosing abnormality of a cooling system for an internal combustion engine, wherein the cooling system includes a radiator, a circulation line system, which circulates coolant through the internal combustion engine and the radiator and includes a bypass fluid line that bypasses the radiator, a flow rate control means for controlling a bypass flow rate of the coolant flowing through the bypass fluid line, and a coolant temperature sensor, which measures a coolant temperature of the coolant in the circulation line system, the abnormality diagnosis apparatus comprising:

a coolant temperature control means for controlling the coolant temperature of the coolant in the circulation line system by controlling the flow rate control means; and

an abnormality diagnosis means for diagnosing the flow rate control means to determine whether abnormality of the flow rate control means exists based on behavior of the measured coolant temperature, which is measured through the coolant temperature sensor during a warm-up period of the internal combustion engine;

wherein when the abnormality diagnosis means diagnoses the flow rate control means, the coolant temperature control means controls the flow rate control means in such a manner that the flow rate control means stops flow of the coolant to the radiator and sets the bypass flow rate of the coolant to a level less than the bypass flow rate set for a period after the warm-up period of the internal combustion engine.

9. (Currently Amended) ~~The~~An abnormality diagnosis apparatus according ~~to~~as in claim 8, wherein when the abnormality diagnosis means diagnoses the flow rate control means, the coolant temperature control means sets the bypass flow rate of the coolant to a level that prevents seizing of the internal combustion engine.

10. (Currently amended) A cooling system for an internal combustion engine, the cooling system comprising:

a radiator;

a circulation line system, which circulates liquid coolant through the internal combustion engine and the radiator and includes a bypass fluid line that bypasses the radiator;

a flow rate control means for controlling a bypass flow rate of the liquid coolant flowing through the bypass fluid line, wherein the flow rate control means continuously changes the bypass flow rate of the coolant;

a coolant temperature sensor, which measures a coolant temperature of the coolant in the circulation line system;

a coolant temperature control means for controlling the coolant temperature of the coolant in the circulation line system by controlling the flow rate control means; and

an abnormality diagnosis means for diagnosing the flow rate control means to determine whether abnormality of the flow rate control means exists based on behavior of the measured coolant temperature, which is measured through the coolant temperature sensor during a warm-up period of the internal combustion engine.

11. (Currently Amended) ~~The~~A cooling system ~~according to~~as in claim 10, wherein the flow rate control means includes at least one of a valve and a pump inserted in the circulation line system.

12. (New) A cooling system as in claim 10, wherein the coolant temperature sensor is positioned between the internal combustion engine and the radiator.

13. (New) A cooling system as in claim 10, wherein the abnormality diagnosis means determines the existence of the abnormality of the flow rate control means based on one of:

an amount of change in the measured coolant temperature measured through the coolant temperature sensor; and

a rate of change in the measured coolant temperature measured through the coolant temperature sensor.

14. (New) A cooling system as in claim 10, wherein the flow rate control means is a control valve that has a continuously variable degree of opening.

15. (New) A method for diagnosing abnormality of a recirculating liquid cooling system for an internal combustion engine, wherein the cooling system includes a radiator, a circulation line system which circulates liquid coolant through the internal combustion engine, radiator and a bypass fluid line that bypasses the radiator and a coolant temperature sensor, said method comprising:

controlling coolant temperature by controlling flow rate of liquid through said bypass fluid line; and

determining whether an abnormality exists based on behavior of the measured coolant temperature, measured by the coolant temperature sensor during a warm-up period of the internal combustion engine.

16. (New) A method as in claim 15 wherein the control of bypass flow rate utilizes at least one of a valve and a pump disposed in the circulation line system.

17. (New) A method as in claim 15 wherein the abnormality determination is based on one of:

change in the measured coolant temperature and
rate of change in the measured coolant temperature.

18. (New) A method as in claim 15 wherein an abnormality diagnosis condition is set and used to determine the existence of the abnormality based on:

a first parameter which relates to heat generated by the internal combustion engine; and

a second parameter which relates to heat released from the coolant.

19. (New) A method as in claim 18 wherein:

an estimated coolant temperature of the coolant in the circulation line system is estimated based on the first parameter and the second parameter; and

existence of the abnormality is determined using a comparison of estimated coolant temperature and measured coolant temperature.

20. (New) A method as in claim 15

wherein an abnormality diagnosis condition is corrected before being used to determine the existence of the abnormality based at least on one of:

the bypass flow rate; and

a bypass flow rate parameter which correlates with the bypass flow rate.

21. (New) A method as in claim 20 wherein a controlled variable related to the controlled flow rate is used as the bypass flow rate parameter.

22. (New) A method as in claim 15

wherein, when the abnormality is being diagnosed, flow rate is controlled such that the flow of coolant to the radiator is stopped and bypass flow rate is set to a level less than that set for use after the warm-up period of the internal combustion engine.

23. (New) A method as in claim 22 wherein, when the abnormality is being diagnosed, the bypass flow rate of coolant is set to a level that prevents seizing of the internal combustion engine.

24. (New) A method for operating a recirculating liquid cooling system for an internal combustion engine, said method comprising:

circulating liquid coolant through the internal combustion engine and a circulation line system including a radiator and a bypass fluid line that bypasses the radiator;

controlling a variable flow rate of liquid coolant flowing through the bypass fluid line;

measuring coolant temperature;

controlling the coolant temperature by variably controlling the bypass flow rate;
and

determining whether abnormality of flow rate control exists based on behavior of the coolant temperature during a warm-up period of the internal combustion engine.

25. (New) A method as in claim 24 wherein variable control of flow rate includes use of at least one of a valve and a pump disposed in the circulation line system.

26. (New) A method as in claim 24 wherein the coolant temperature sensor is positioned between the internal combustion engine and the radiator.

27. (New) A method as in claim 24 wherein the determination of an abnormality is based on at least one of:

change in the measured coolant temperature; and
rate of change in the measured coolant temperature.

28. (New) A method as in claim 24 wherein variable flow rate control is achieved using a control valve that has a continuously variable degree of opening.